In situ techniques for inferring SSH

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Credit: NASA Blue Marble Project

In situ measurements to infer SSH

- Inference through dynamical balance/simple models (e.g., inversion from drifter trajectories or Helmholtz decomposition of surface current transects)
- Bottom-mounted inverted echo sounders with pressure recorders (Watts et al.)
- Differential GPS (Bonnefond et al.)
- Hydrographic (temperature/salinity) measurements for dynamic height; includes measurements from ships, moorings, profiling floats, and gliders

PIES (Pressure-recording Inverted Echo Sounder)

Watts et al. talk following

- Emits 12 kHz sound pulses
- Measures τ = round-trip travel time from bottom to surface
- Measures bottom pressure (P_{bot}) – resolution < 1 mm
- A robust empirical relationship exists between τ and vertical profiles T(P), S(P)

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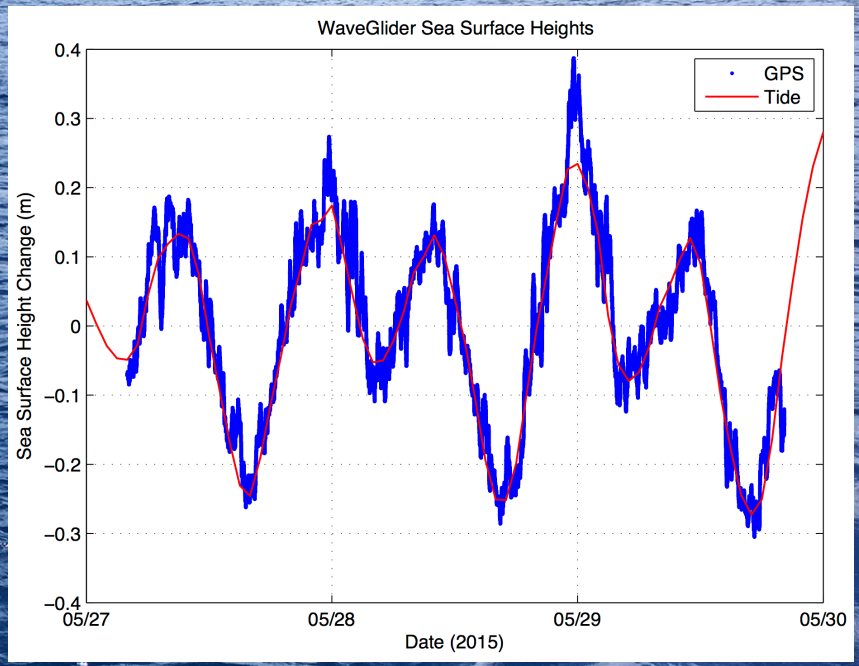
Mobile platforms with differential GPS



An array of autonomous mobile platforms, like wave gliders, might help capture synoptic SSH; needs to be evaluated

(James Foster, Hawaii Inst of Geophys and Planetology; Dave Fratantoni, Seatrec)

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Hydrographic measurements for dynamic height

Ships are one of the fastest moving mobile platforms for collecting hydrographic measurements

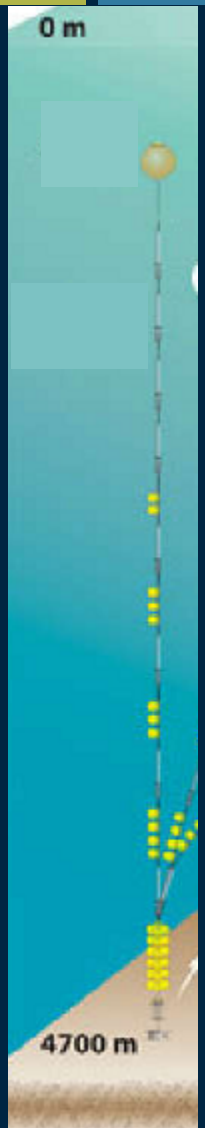
Image from TeledyneOceanScience

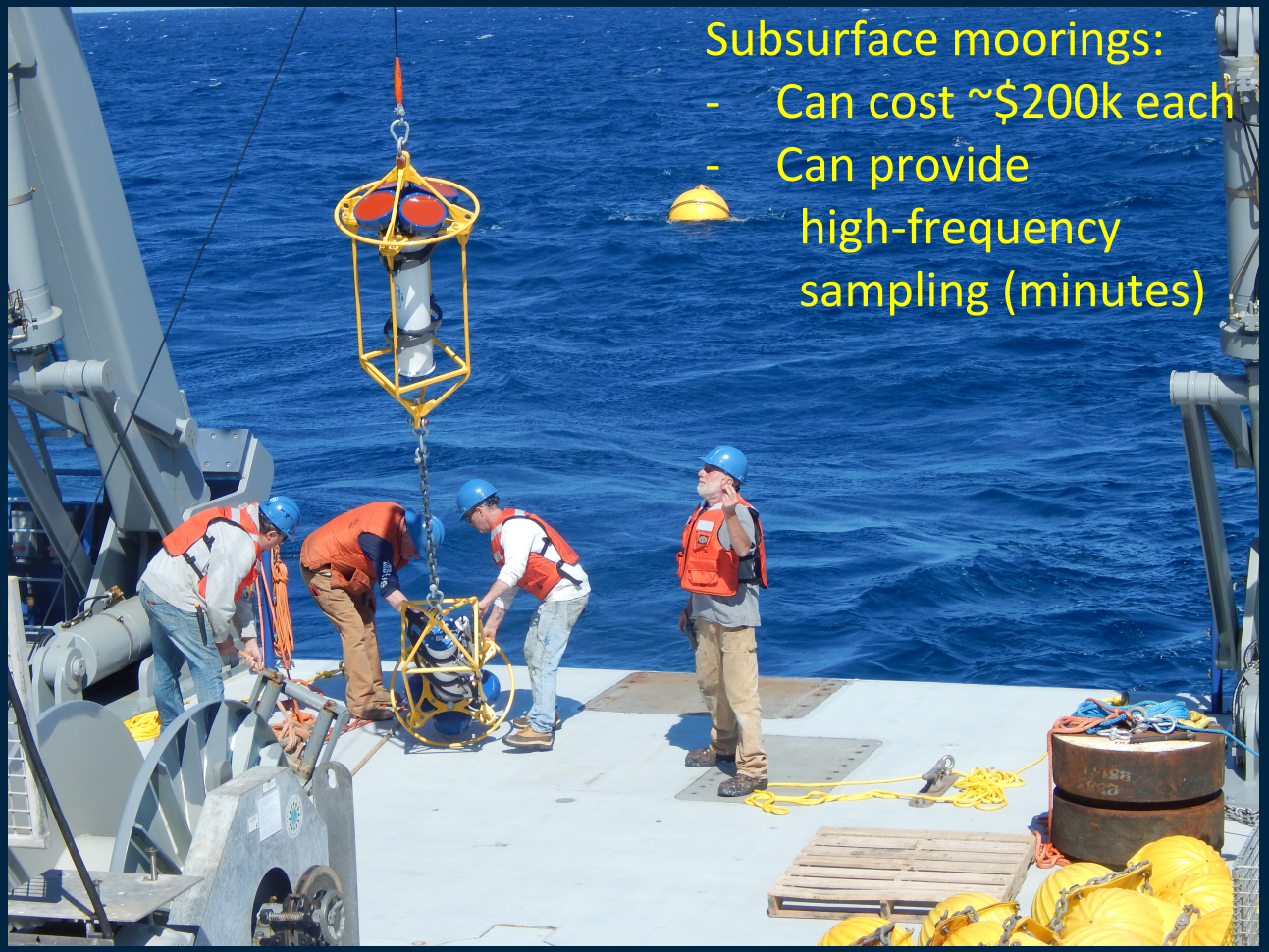
Hydrographic measurements for dynamic height

Shipboard hydrographic measurements involve an inherent trade-off of profile depth and ship speed. Table below is for a particular underway measurement system (OceanScience Underway CTD)

	Profile Depth (m)							
Speed (kts)	300	400	500	600	700	800	900	1000
0								
2								
4								
6								
8								
10								
12								

Mooring measurements for dynamic height



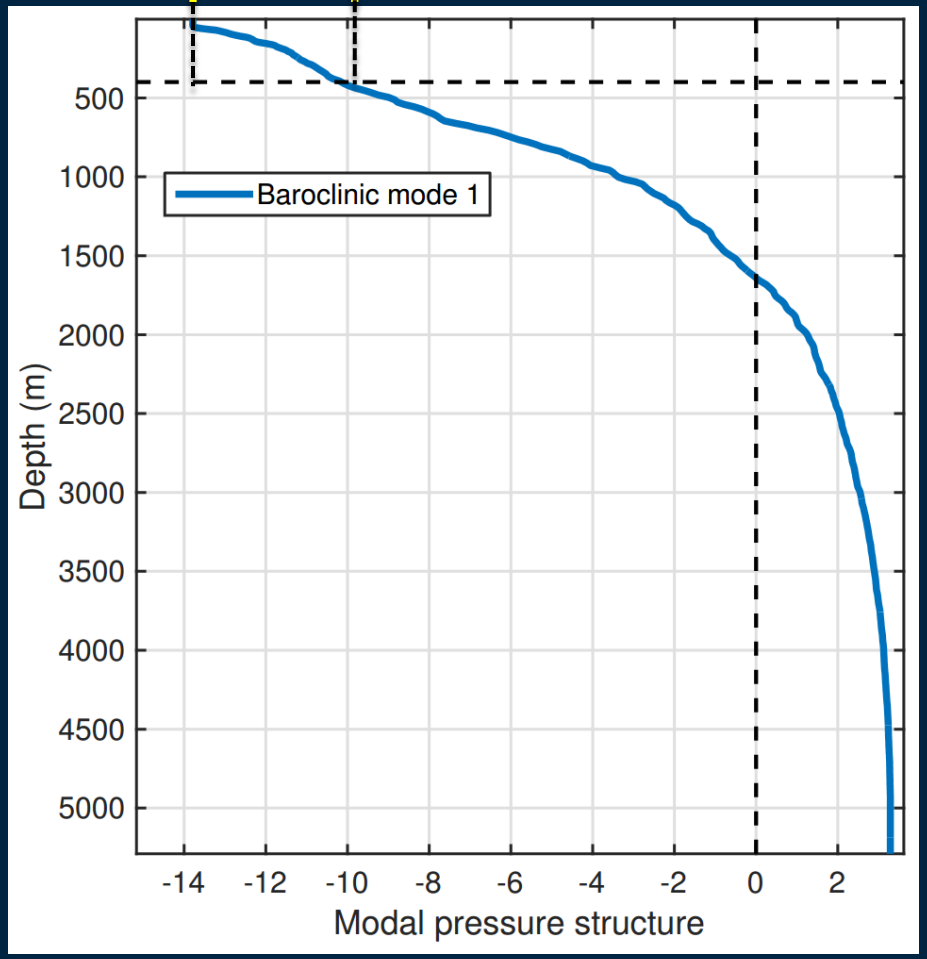


Subsurface moorings:

- Can cost ~$200k each
- Can provide high-frequency sampling (minutes)

Relationship of dynamic height to SSH

Pressure difference between surface and reference depth



← Reference depth

Relationship of dynamic height to SSH

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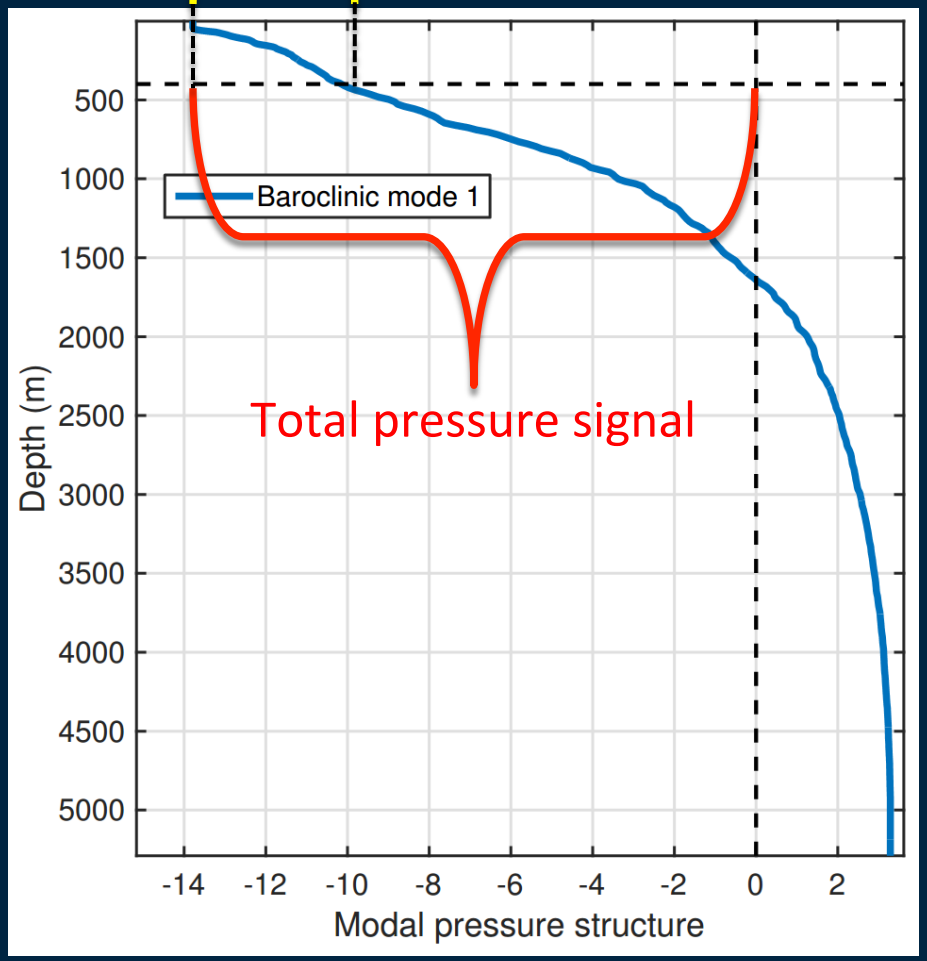
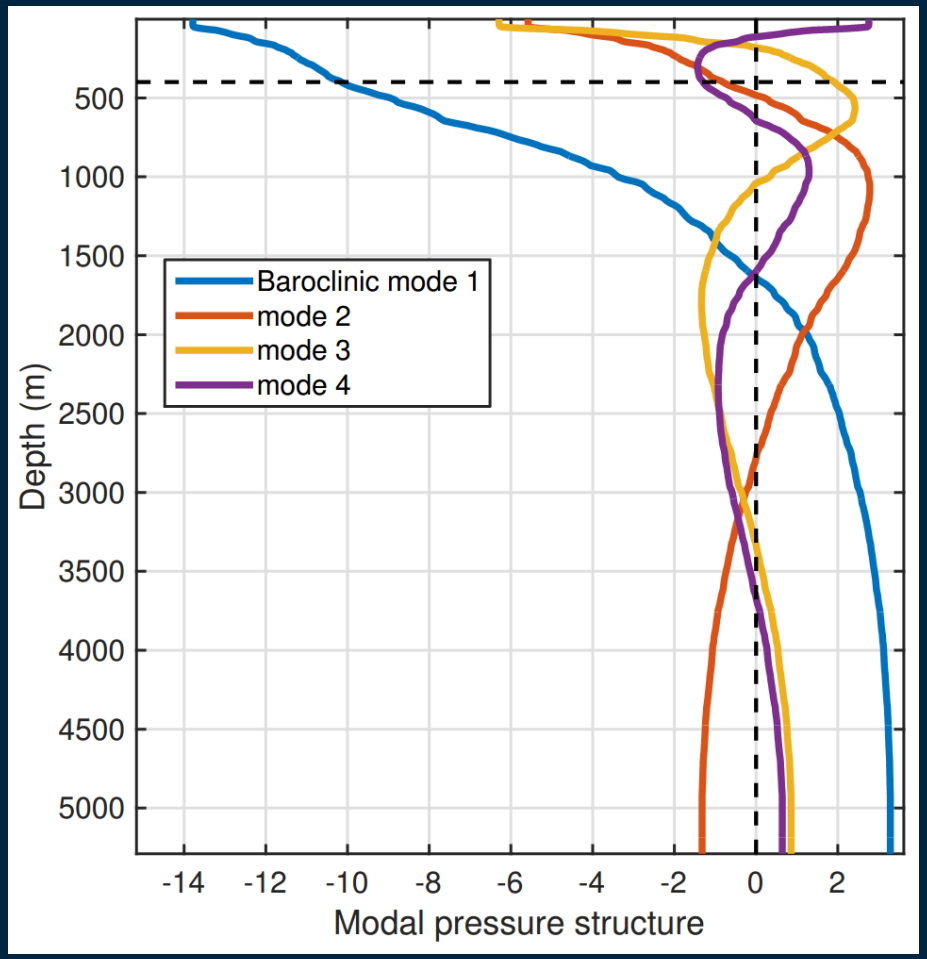


If we knew the vertical structure of the baroclinic pressure signal (and the barotropic pressure signal), it would be simple to relate dynamic height to SSH

Relationship of dynamic height to SSH



So, how can we relate dynamic height to SSH?

Two approaches:

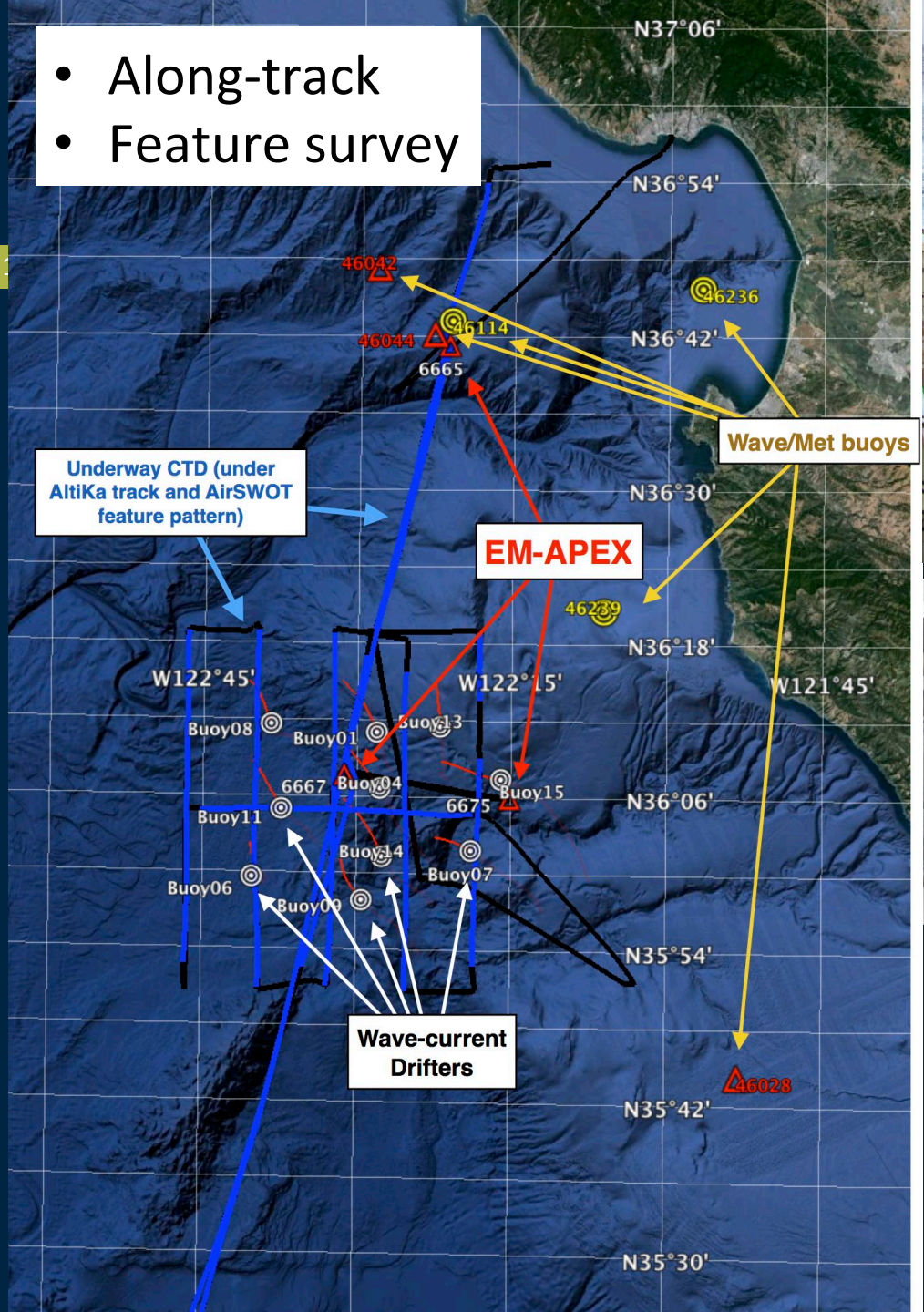
(1) Compute dynamic height relative to a known pressure (either measure bottom pressure or assume pressure fluctuation is zero at some depth)

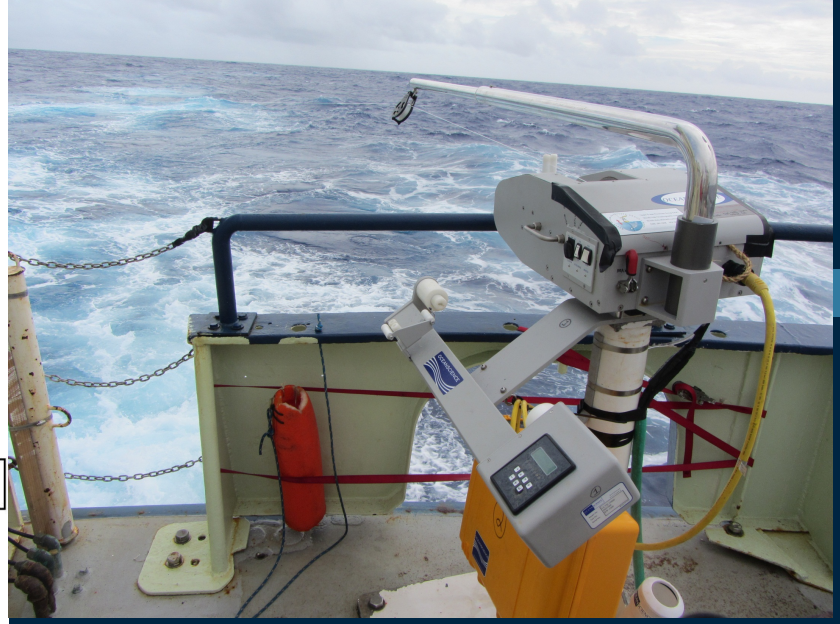
(2) Given knowledge of contribution of different modes to dynamic height, convert dynamic height signal of each mode to SSH

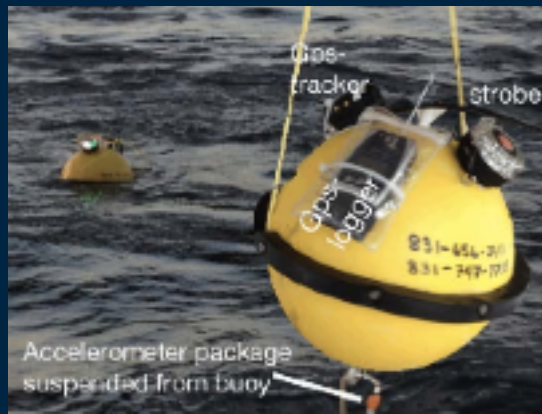
AirSWOT Ocean In Situ Sampling Objectives

- Provide SSH information (including both in situ and ancillary estimates) to help understand AirSWOT performance
- Provide surface velocity data to assess/correct the effect on AirSWOT measurements

- Along-track
- Feature survey





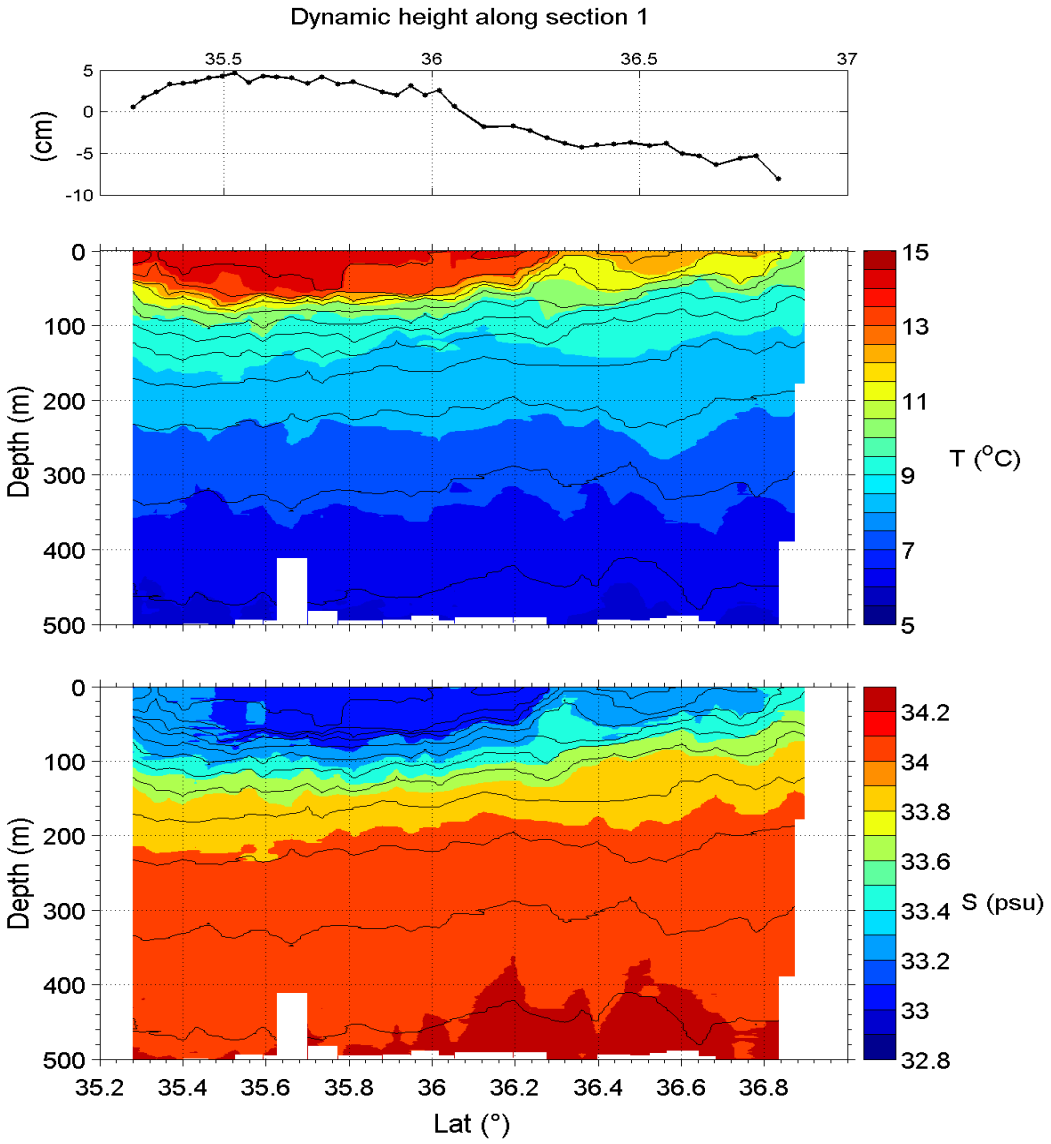


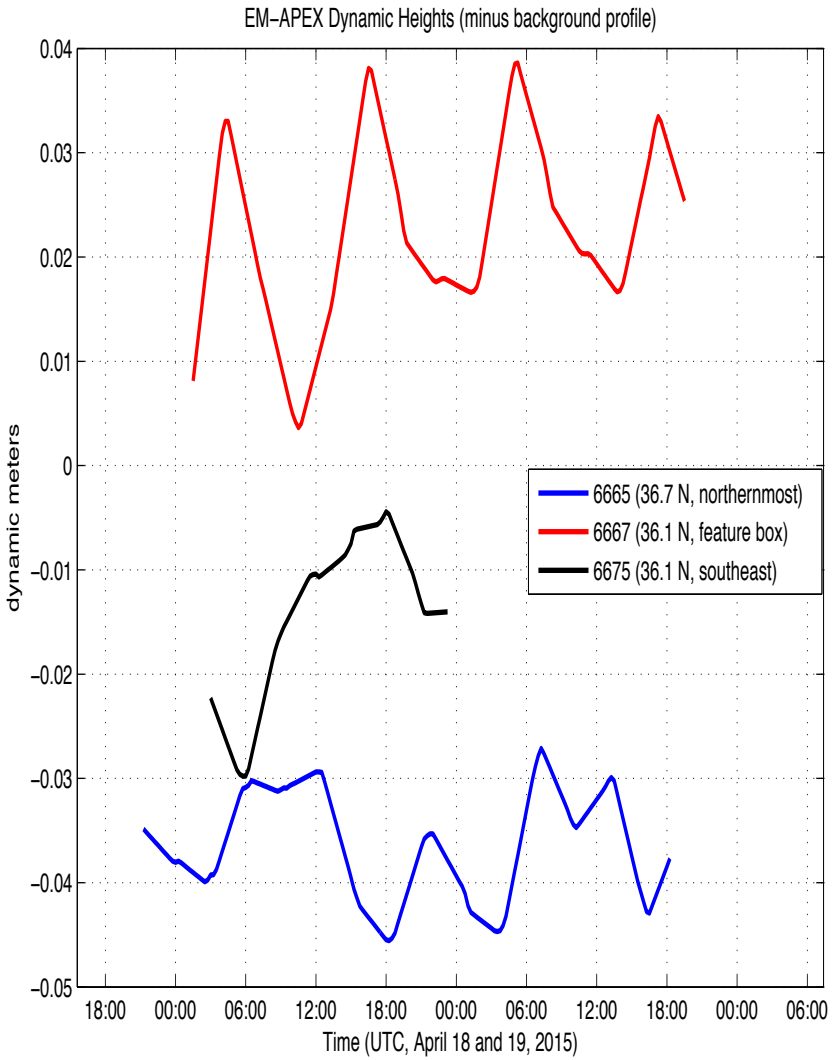
From Underway CTD:

- 10 cm SSH north-south gradient along-track

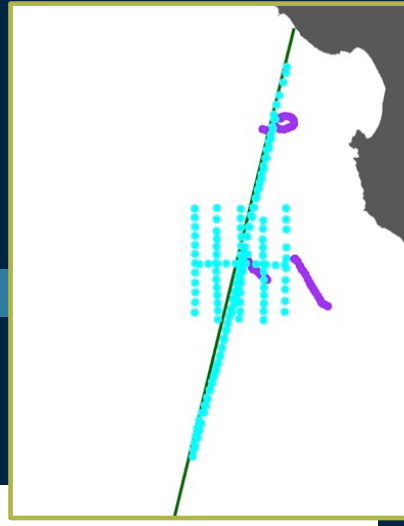
From James Girton's EM-APEX floats:

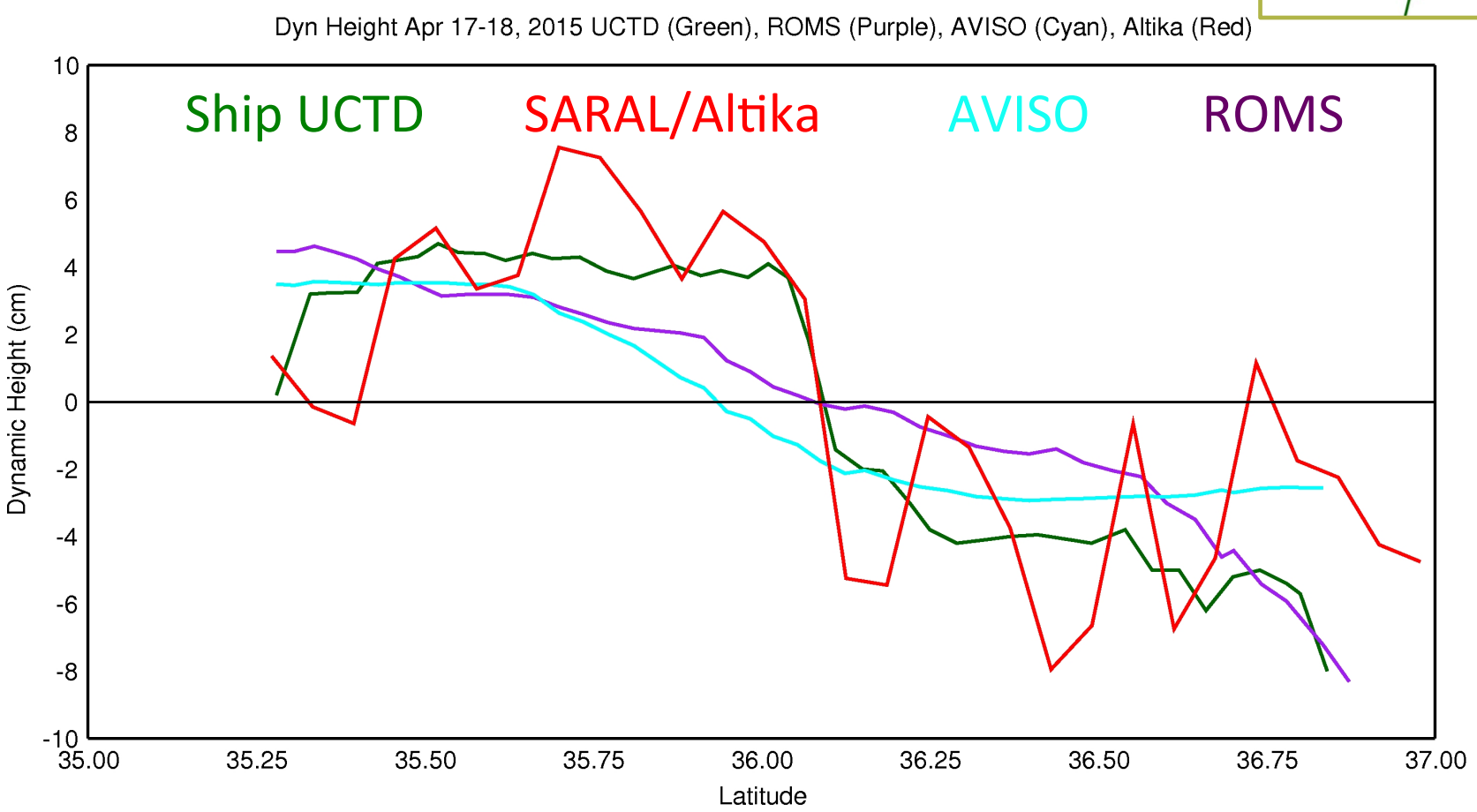
- 6 cm SSH north-south gradient
- 3 cm SSH due to internal tides/waves





Along-track (SARAL/Altika) SSH on 17 April

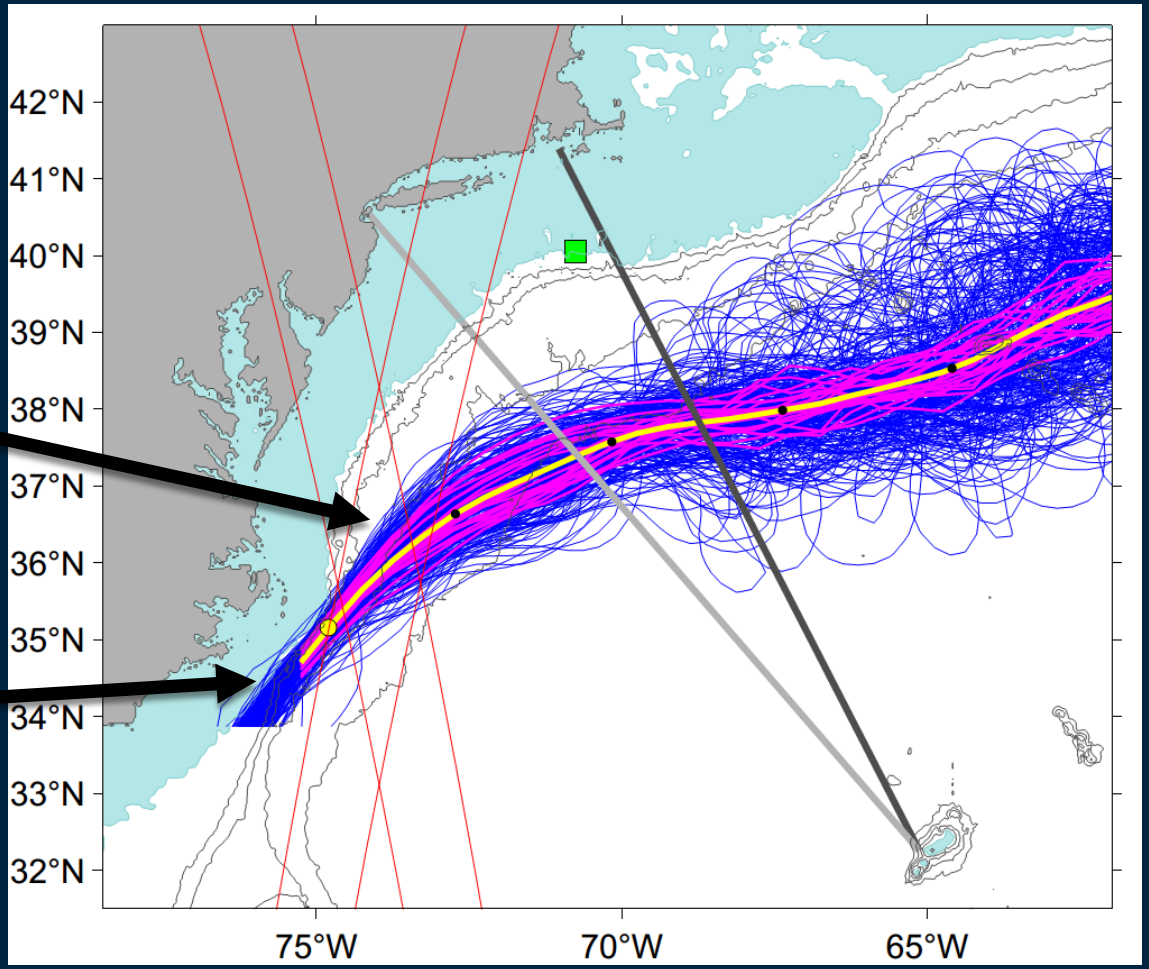




Gulf Stream challenges for in situ measurements

SWOT fast-repeat orbit crossover

Gulf Stream center position from AVISO/ DUACS product



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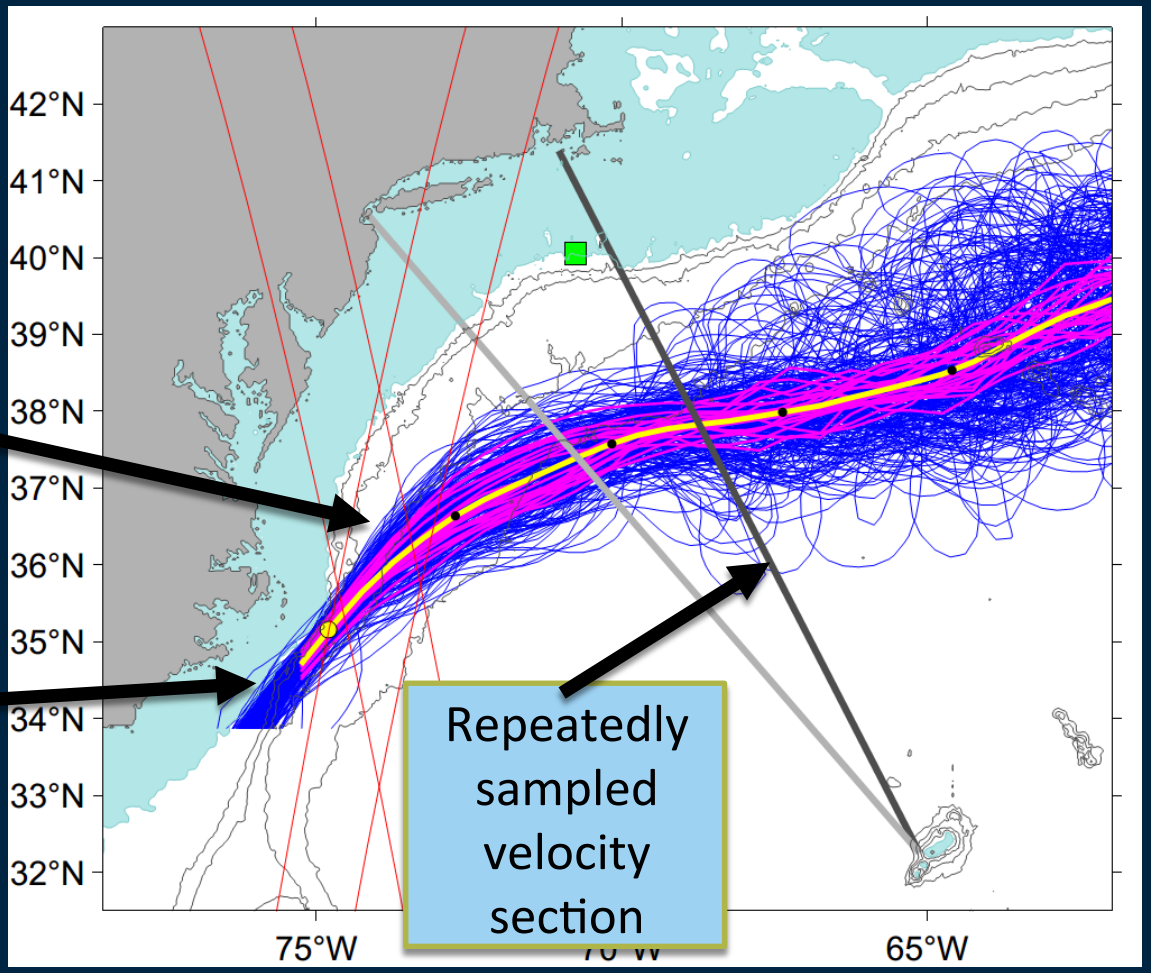

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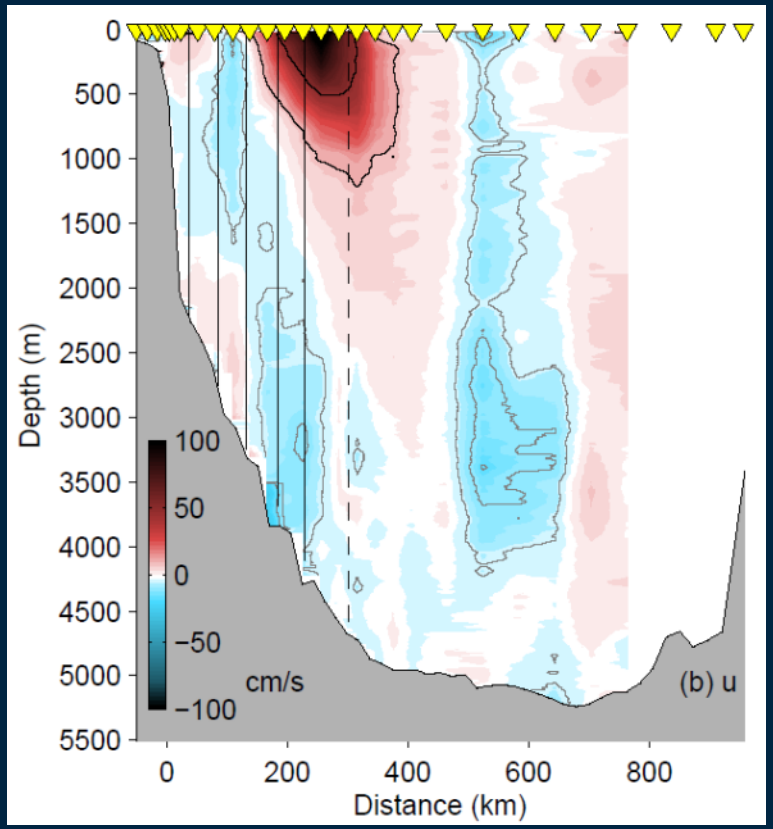
Gulf Stream challenges for in situ measurements

1 m/s=86.4 km/day
→ Major challenge for drifters, floats, gliders



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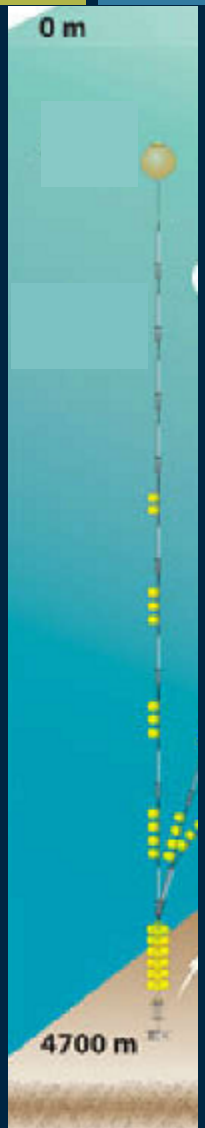

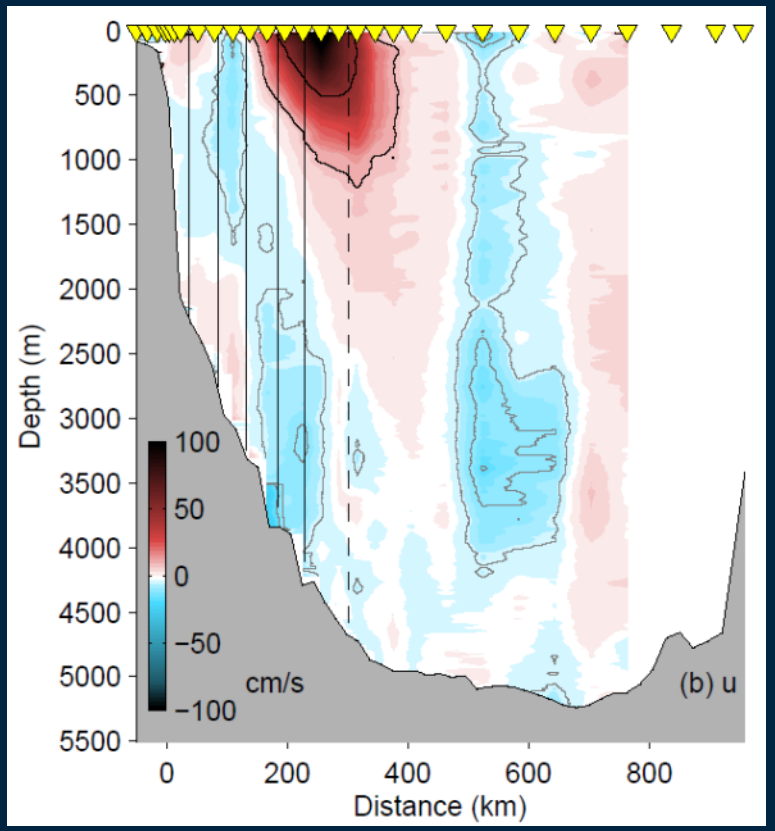

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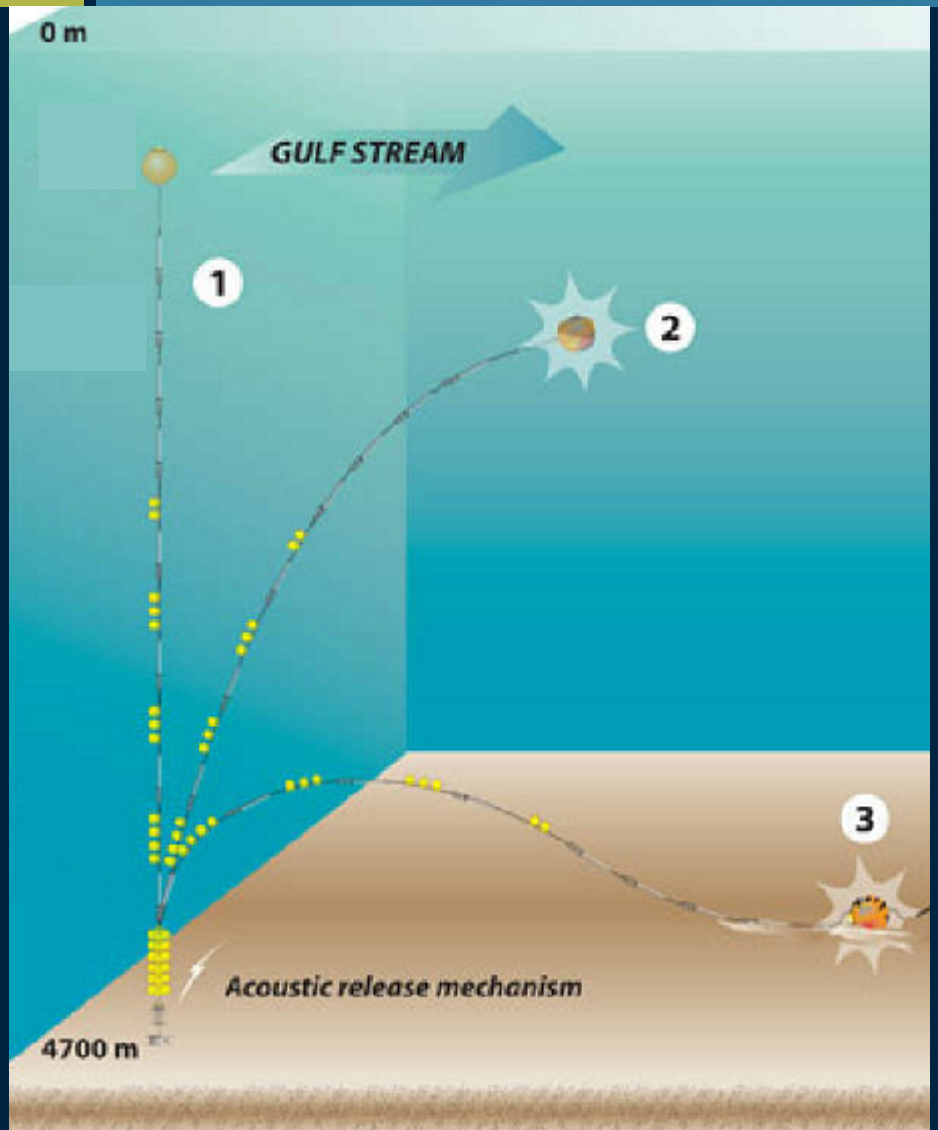

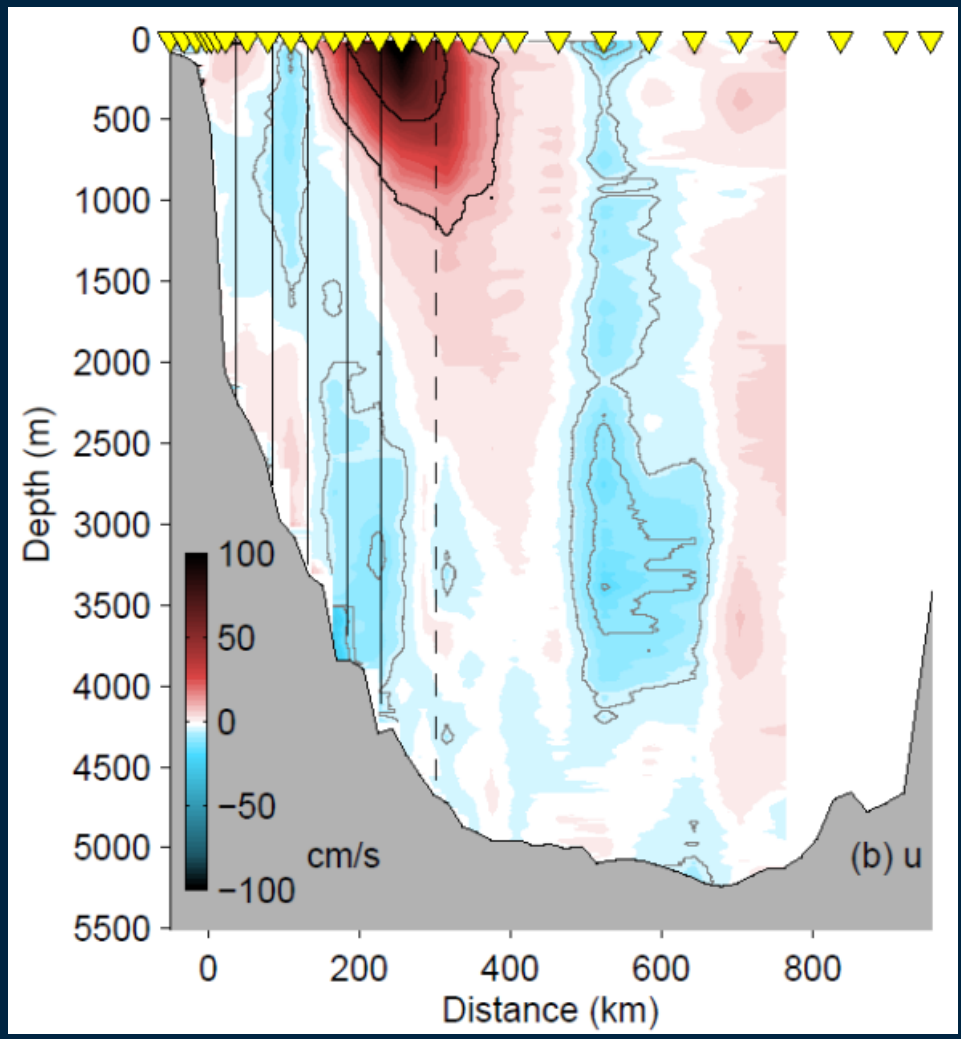

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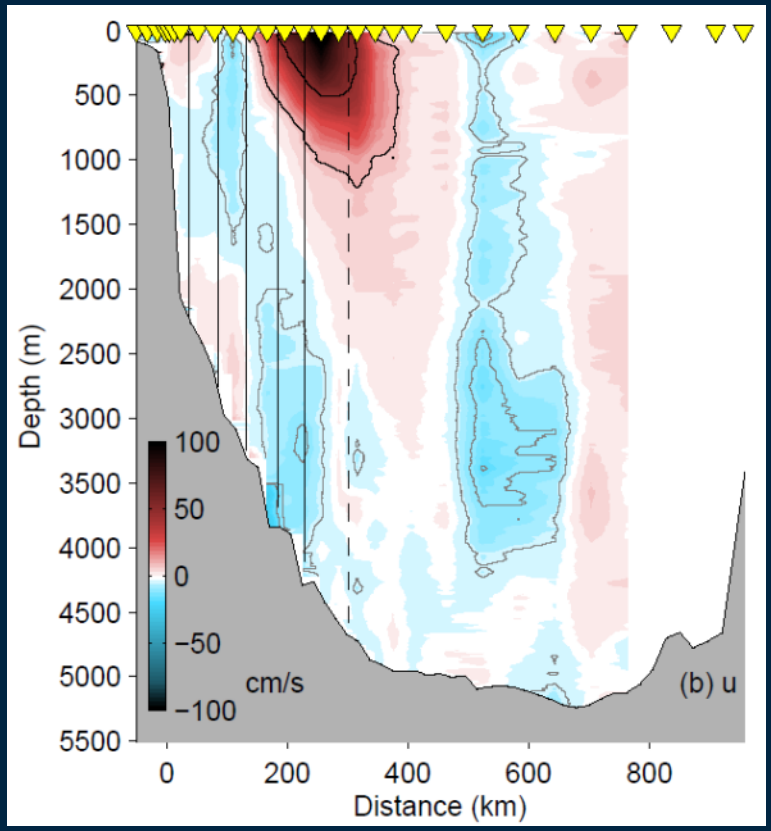
Gulf Stream challenges for in situ measurements

(Currents in cm/sec)

Depth(m)	0 current	High current	Med current	Low current
0	0	150	100	50
600	0	100	65	35
1000	0	60	40	20
3000	0	40	25	15
4700	0	35	20	12
Sphere Depth(m) (Top of Mooring)	50	506	230	72



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Conclusions

- Hydrographic measurements provide an indirect measure of the baroclinic SSH signal
- There will be missing information from barotropic variability and unknown pressure at the reference depth– this can be a large “SSH” error
- Moorings can provide synoptic sampling, every few minutes for a year, but the number of sites would be limited

Vertical modes for April AirSWOT campaign